

Reduction in blood pressure with a low sodium, high potassium, high magnesium salt in older subjects with mild to moderate hypertension

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Abstract

Objective—To examine the effect of a reduced sodium and increased potassium and magnesium intake on blood pressure.

Design—Randomised double blind placebo controlled trial.

Setting—General population of a suburb of Rotterdam.

Subjects—100 men and women between 55 and 75 years of age with untreated mild to moderate hypertension.

Interventions—During 24 weeks the intervention group received a mineral salt (sodium: potassium: magnesium 8:6:1) and foods prepared with the mineral salt. Controls received common salt and foods.

Main outcome measure—Change in blood pressure.

Results—Complete follow up was achieved for 97 of the 100 randomised subjects. Systolic blood pressure (mean of measurements at weeks 8, 16, and 24) fell by 7.6 mm Hg (95% confidence interval 4.0 to 11.2) and diastolic blood pressure by 3.3 mm Hg (0.8 to 5.8) in the mineral salt group compared with the controls, with a 28% decrease in urinary sodium excretion and a 22% increase in urinary potassium excretion. Twenty five weeks after the study the difference in blood pressure between the groups was no longer detectable.

Conclusion—Replacing common sodium salt by a low sodium, high potassium, high magnesium mineral salt could offer a valuable non-pharmacological approach to lowering blood pressure in older people with mild to moderate hypertension.

Introduction

Results from many studies suggest a role for minerals in blood pressure regulation. Sodium may increase blood pressure,¹ whereas the reverse has been reported for potassium and magnesium.^{2,3} Several studies have shown a stronger relation of the sodium to potassium ratio with blood pressure than sodium or potassium alone.⁴⁻⁶ Hence dietary measures to reduce blood pressure might be more effective when the intake of several minerals is changed simultaneously.

Older people with high blood pressure may benefit most from salt restriction, as the strength of the association between sodium and blood pressure increases with age and blood pressure in cross sectional studies.^{4,7} Results of intervention studies support this hypothesis, though most trials have focused on young and middle aged subjects.^{8,9} Intervention studies in elderly people addressing multiple modest changes in mineral intake are needed to assess the potential of this intervention for blood pressure lowering at advanced age.

We conducted a randomised double blind placebo controlled trial of the effect of a reduced sodium intake and increased potassium and magnesium intake on blood pressure by using a mineral salt (sodium: potassium: magnesium 8:6:1) in older subjects with mild to moderate hypertension.

Subjects and methods

Subjects were recruited from the population based cohort of the Rotterdam study, which consists of non-hospitalised older inhabitants of a suburb of Rotterdam. Details of the study have been reported.^{10,11} All subjects had their blood pressure measured between 1990 and 1992. Men and women aged 55-75 with a blood pressure above 140 mm Hg systolic or 85 mm Hg diastolic without antihypertensive treatment (n=419) were invited by letter and telephone for remeasurement of blood pressure. To be eligible for the trial subjects' systolic blood pressure had to be between 140 and 200 mm Hg or diastolic pressure between 85 and 110 mm Hg at two measurements one week apart. In addition, systolic blood pressure had to be not below 130 mm Hg and diastolic pressure not below 70 mm Hg.

Subjects with a history of myocardial infarction, angina pectoris, diabetes mellitus, or impaired renal function (serum creatinine concentration > 200 µmol/l) or eating a salt restricted diet on medical advice were excluded. Thirty subjects could not be contacted. A total of 125 subjects were excluded after being contacted by telephone because they showed no interest (n=56) or because they met one of the exclusion criteria (n=69). Of the 264 subjects who eventually had their blood pressure remeasured (63% of those initially invited), 17 did not fulfil blood pressure criteria, 40 had started antihypertensive treatment, 55 met other exclusion criteria, and 52 refused the trial. This left 100 subjects who were randomised.

PROTOCOL

Randomisation was carried out within eight strata defined by sex and baseline blood pressure by using a computerised randomisation table. During 24 weeks the intervention group received a mineral salt (sodium: potassium: magnesium 8:6:1 mmol; SagaSalt (Akzo Nobel, Netherlands)) for use in cooking and at the table and foods prepared with the mineral salt. The control group received common salt (sodium chloride) and foods prepared with common salt. The mineral salt is extracted from natural sources in Iceland and consists of 41% sodium chloride, 41% potassium chloride, 17% magnesium salts, partly as potassium-magnesium double salts (carnallite and kainite), and 1% trace minerals.¹²

Trial foods included bread, cheese, luncheon meats, canned and instant soups, and smoked sausage. Together these foods provide around 57% of the salt intake of the Dutch elderly population.¹³ The sodium to potassium ratio (mmol:mmol) ranged from 1.3 (cheese) to 1.8 (canned soups) in mineral salt foods and from 6.7 (smoked sausage) to 22.7 (instant soups) in control foods. Salt and foods for both groups looked identical and were provided free of charge by means of a double blind coding system based on the randomisation numbers. Participants were asked to avoid changes in dietary habits and lifestyle, to adhere as much as possible to the trial salt and foods, and to register deviations from the protocol in a diary. For each subject we recorded the amount of foods provided.

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We contacted subjects monthly to check and encourage compliance.

The protocol was approved by the medical ethics committee of Erasmus University. All participants gave written informed consent. During the study participants were not told the results of blood pressure measurements.

MEASUREMENTS

Blood pressure, pulse rate, and body weight were assessed at baseline and after 8, 16, and 24 weeks of intervention. To obtain stable estimates blood pressure and pulse rate were measured at two visits with a week's interval (baseline, week 8, and week 16) or at three visits with weekly intervals (week 24) and the average taken as the estimate. Baseline blood pressure was the average of the last blood pressure screening and baseline measurements. Blood pressure was measured on the right arm by two investigators using an automatic device (Dinamap model 8100; Criticon Inc, Florida) and a 51 cm by 15 cm cuff while the subject was seated. After at least five minutes' rest four measurements were taken, of which the last three were averaged. Body weight and height were measured without heavy clothing and shoes. Body mass index was computed as weight (kg) divided by height (m) squared. Subjects collected two successive 24 hour urine samples at baseline and at 8, 16, and 24 weeks.

Every eight weeks the subjects answered a questionnaire on health complaints, smoking, alcohol intake, physical activity, and drug use during the preceding period. At eight weeks subjects evaluated the appearance, saltiness, and palatability of the trial foods by filling in a questionnaire with five point rating scales. During intervention a dietitian visited the subjects at home and used a sensitive balance to weigh the amount of trial salt added during cooking (PM 300 balance; Mettler-Toledo AG, Switzerland). Information on salt use was also obtained by means of a questionnaire.

We sampled blood at baseline and at 24 weeks. Serum ionised calcium concentration was analysed with an ion selective electrode (ICA2 Ionized Calcium Analyzed, Radiometer, Copenhagen), and reported values are pH adjusted. Analyses of other electrolytes in blood and urine were performed by standard methods. Four to nine months after the study all subjects were invited again for blood pressure measurement. On this occasion we asked which salt the subjects thought he or she had received during the study.

DATA ANALYSIS

Changes in blood pressure and electrolyte excretion from baseline were compared between the control group and the mineral salt group. In addition, pre-planned subgroup analyses were performed according to sex and age. The hypothesis of no difference between the groups was tested by a two sided *t* test. Results are expressed as means and 95% confidence intervals of the differences between groups. Adjustment of change in blood pressure for potential confounders was performed by analysis of covariance. Data analysis was carried out on an intention to treat basis. The study sample was large enough to detect a difference in blood pressure of 5 mm Hg systolic and 4 mm Hg diastolic with a power of 0.90 and a two sided *P* value of 0.05.

Results

Complete follow up was achieved by 97 of the 100 randomised subjects. Two of the controls withdrew after eight and 16 weeks because of admission to hospital for complaints not related to intervention.

One person withdrew in the mineral salt group after six weeks because of dislike of the foods.

Randomisation established comparable study groups (table I). Figure 1 presents blood pressure at baseline and during intervention. A difference in blood pressure change between the groups was present at eight weeks and persisted throughout. Systolic blood pressure (mean of measurements at weeks 8, 16, and 24) fell by 7.6 mm Hg (95% confidence interval 4.0 to 11.2; *P* < 0.001) and diastolic pressure by 3.3 mm Hg (0.8 to 5.8; *P* = 0.009) in the mineral salt group compared with the controls. After adjustment for

TABLE I—Baseline characteristics of subjects in control and mineral salt groups. Except where stated otherwise values are means (SD)

| | Controls (n=51) | Mineral salt group (n=49) |
|--------------------------------------|--------------------|---------------------------------|
| No of men/women | 25/26 | 26/23 |
| Age (years) | 67.1 (4.5) | 65.7 (4.6) |
| Blood pressure (mm Hg): | | |
| Systolic | 157.5 (12.8) | 158.0 (15.0) |
| Diastolic | 90.8 (8.9) | 89.8 (9.6) |
| Pulse rate (beats/min) | 80.6 (12.6) | 77.7 (12.6) |
| Height (cm) | 167.0 (9.1) | 169.2 (9.4) |
| Body weight (kg) | 76.0 (11.3) | 77.5 (10.1) |
| Body mass index (kg/m ²) | 27.2 (3.2) | 27.1 (3.4) |
| No (%) of cigarette smokers | 12 (23.5) | 9 (18.4) |
| Serum: | | |
| Sodium (mmol/l) | 137.1 (2.4) | 137.0 (3.1) |
| Potassium (mmol/l) | 4.2 (0.4) | 4.3 (0.3) |
| Magnesium (mmol/l) | 0.86 (0.06) | 0.86 (0.06) |
| Calcium (mmol/l) | 2.4 (0.1) | 2.4 (0.1) |
| Ionised calcium (mmol/l) | 1.24 (0.04) | 1.24 (0.04) |
| Urine: | | |
| Sodium (mmol/24 h) | 138 (50) | 139 (52) |
| Potassium (mmol/24 h) | 81 (25) | 86 (22) |
| Sodium:potassium ratio | 1.8 (0.6) | 1.6 (0.4) |
| Magnesium (mmol/24 h) | 5.2 (1.7) | 5.4 (1.9) |
| Calcium (mmol/24 h) | 4.8 (2.2) | 4.7 (1.9) |
| Creatinine (mmol/24 h) | 10.2 (2.8) | 10.0 (2.7) |

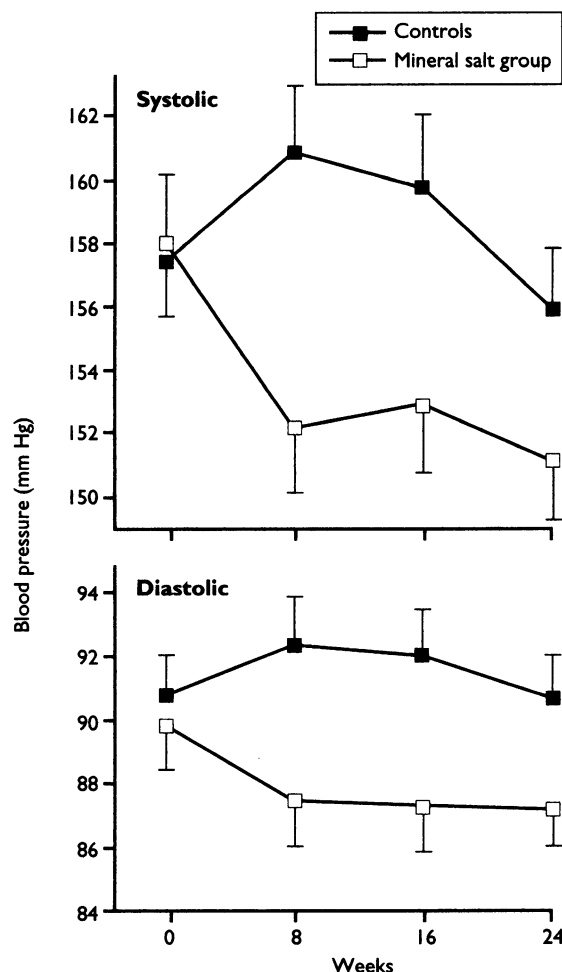


FIG 1—Mean systolic and diastolic blood pressure at baseline and during intervention in controls (n=51) and subjects in mineral salt group (n=49). Bars are SEM

change in body weight values were 8.7 and 3.6 mm Hg (table II). The decrease in blood pressure was of the same magnitude in men and women and not modified by age (data not shown).

Table III shows the changes in body weight and electrolyte excretion from baseline. The 24 hour sodium excretion decreased on average by 28% (that is, by 38.4 mmol (95% confidence interval 24.0 to 52.8); $P < 0.001$) and potassium excretion increased by 22% (17.5 mmol (7.9 to 27.0); $P < 0.001$) in the mineral salt group compared with the controls (fig 2). Urinary calcium and magnesium excretion did not change. Results were similar after adjustment for urinary creatinine excretion. Urinary volumes in both groups remained stable during intervention (data not shown). Change in body weight was on average 0.50 kg (95% confidence interval -0.03 to 1.03; $P = 0.06$) more in the mineral salt group than in the control group. Serum electrolyte concentrations (table IV) were unchanged in both groups. Change in pulse rate during intervention was not significantly different between the groups (data not shown).

Appearance, saltiness, and palatability of the trial foods were rated equally by the two groups except for the bread and table salt, which were considered less

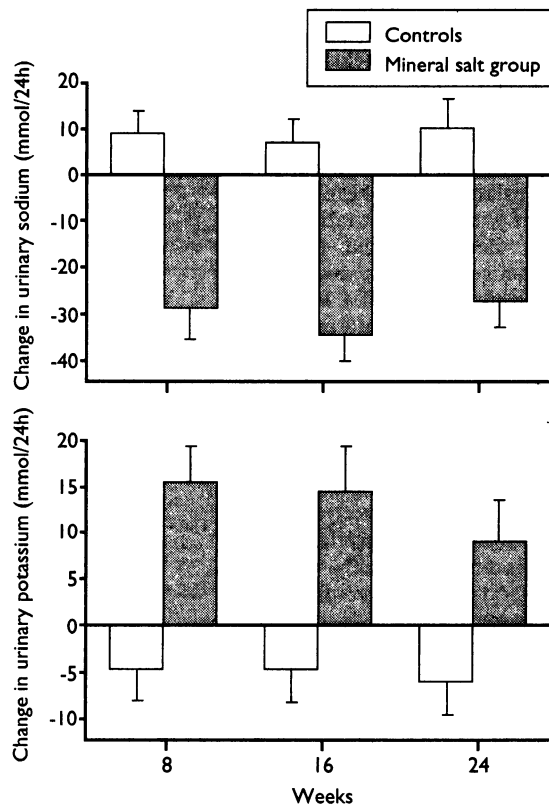


FIG 2—Mean changes in 24 hour urinary sodium and potassium excretion in controls ($n=51$) and subjects in mineral salt group ($n=49$). Bars are SEM. Differences from baseline between groups were significant at each point ($P < 0.01$)

TABLE II—Changes in blood pressure from baseline (51 controls, 49 subjects in mineral salt group). Values are means (SD) adjusted for body weight

| | Week 0 | Week 8 | Week 16† | Week 24‡ | Intervention§ |
|--------------------------------------|-------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Systolic blood pressure (mm Hg): | | | | | |
| Controls | 157.6 (2.0) | 161.0 (2.1) | 160.0 (2.2) | 156.0 (1.9) | 158.5 (1.8) |
| Mineral salt group | 157.9 (2.0) | 151.8 (2.1) | 152.6 (2.2) | 150.9 (1.9) | 151.7 (1.8) |
| Difference (95% confidence interval) | | -9.7 (-13.6 to -5.7) $P < 0.001$ | -8.7 (-13.0 to -4.5) $P < 0.001$ | -7.7 (-12.3 to -3.1) $P = 0.001$ | -8.7 (-12.2 to -5.2) $P < 0.001$ |
| Diastolic blood pressure (mm Hg): | | | | | |
| Controls | 91.0 (1.3) | 92.7 (1.4) | 92.3 (1.4) | 90.9 (1.2) | 92.1 (1.2) |
| Mineral salt group | 89.7 (1.3) | 87.0 (1.4) | 86.7 (1.4) | 86.8 (1.2) | 86.9 (1.2) |
| Difference (95% confidence interval) | | -4.2 (-7.0 to -1.4) $P = 0.004$ | -4.0 (-7.1 to -0.9) $P = 0.01$ | -2.8 (-5.8 to 0.2) $P = 0.06$ | -3.6 (-6.0 to -1.1) $P = 0.005$ |

†Values for week 16 were missing for one control and one subject in mineral salt group.
‡Values for week 24 were missing for two controls and one subject in mineral salt group.

§Mean of measurements at weeks 8, 16, and 24.

||Difference in change from baseline between study groups.

TABLE III—Body weight and electrolyte excretion at baseline and during intervention. Values are means (SE)†

| | Week 0 | Week 8 | Week 16 | Week 24 |
|-------------------------|------------|------------|------------|------------|
| Body weight (kg): | | | | |
| Controls | 76.0 (1.6) | 76.1 (1.6) | 76.7 (1.6) | 76.0 (1.7) |
| Mineral salt group | 77.5 (1.4) | 78.4 (1.4) | 78.9 (1.5) | 78.9 (1.4) |
| Sodium (mmol/24h): | | | | |
| Controls | 138 (7) | 147 (7) | 147 (7) | 148 (7) |
| Mineral salt group | 139 (8) | 113 (5) | 107 (5) | 116 (4) |
| Potassium (mmol/24 h): | | | | |
| Controls | 81 (4) | 77 (3) | 77 (4) | 75 (3) |
| Mineral salt group | 86 (3) | 102 (4) | 101 (5) | 97 (4) |
| Sodium:potassium ratio: | | | | |
| Controls | 1.8 (0.1) | 2.0 (0.1) | 1.9 (0.1) | 2.1 (0.1) |
| Mineral salt group | 1.6 (0.1) | 1.1 (0.1) | 1.1 (0.1) | 1.3 (0.1) |
| Magnesium (mmol/24 h): | | | | |
| Controls | 5.2 (0.2) | 5.8 (0.2) | 5.5 (0.3) | 5.4 (0.3) |
| Mineral salt group | 5.4 (0.3) | 6.1 (0.3) | 5.8 (0.3) | 5.7 (0.3) |
| Calcium (mmol/24 h): | | | | |
| Controls | 4.8 (0.3) | 4.8 (0.3) | 4.6 (0.3) | 4.9 (0.2) |
| Mineral salt group | 4.7 (0.3) | 4.4 (0.3) | 4.1 (0.2) | 4.3 (0.3) |

†On each occasion values for body weight and electrolyte excretion were obtained for at least 47 controls and 45 subjects in mineral salt group.

TABLE IV—Serum electrolyte concentrations at baseline and after 24 weeks of intervention. Values are means (SE)

| | Week 0† | Week 24‡ |
|---------------------------|-------------|-------------|
| Sodium (mmol/l): | | |
| Controls | 137.1 (0.4) | 135.4 (0.5) |
| Mineral salt group | 137.0 (0.5) | 135.5 (0.4) |
| Potassium (mmol/l): | | |
| Controls | 4.17 (0.06) | 4.23 (0.05) |
| Mineral salt group | 4.27 (0.04) | 4.35 (0.04) |
| Magnesium (mmol/l): | | |
| Controls | 0.86 (0.01) | 0.82 (0.01) |
| Mineral salt group | 0.86 (0.01) | 0.83 (0.01) |
| Calcium (mmol/l): | | |
| Controls | 2.44 (0.02) | 2.32 (0.01) |
| Mineral salt group | 2.41 (0.02) | 2.35 (0.01) |
| Ionised calcium (mmol/l): | | |
| Controls | 1.24 (0.01) | 1.19 (0.02) |
| Mineral salt group | 1.24 (0.01) | 1.23 (0.02) |

†Values missing for seven controls and four subjects in mineral salt group.

‡Values missing for eight controls and four subjects in mineral salt group.

salty by significantly more people in the mineral salt group than in the control group. None of the participants reported the flavour of the trial salt and foods as unpleasant. Seven per cent of the controls (3/44) reported a higher discretionary salt use during the trial as compared with 40% (16/40) of subjects in the mineral salt group. Salt use as assessed by weighing was similar in both groups—namely, 4.9 g (SD 4.8; range nil to 24.1 g) in the control group and 5.2 g (4.9; nil to 26.2 g) in the mineral salt group ($P = 0.74$).

Reports of side effects and lifestyle changes during intervention were minimal and equally distributed among the study groups. The records of salt and foods provided and the diaries on compliance indicated good adherence to the protocol in both groups.

Twenty five weeks (SD 4; range 16–37) after the study all 51 controls and 46 subjects from the mineral salt group (94%) visited the study centre. Differences in blood pressure change from baseline between the groups were 0.8 mm Hg (95% confidence interval -4.5

to 6.0; $P=0.77$) systolic and -1.0 mm Hg (-4.5 to 2.5 ; $P=0.57$) diastolic in untreated subjects. Sixteen of the controls (31%) compared with 33 (72%) subjects from the mineral salt group believed they had received mineral salt when asked after the trial. Within the study groups, observed blood pressure changes during intervention did not differ between those who thought they had been given mineral salt and those who thought they had been given common salt or did not know.

Discussion

We observed a decrease in systolic and diastolic blood pressure in older hypertensive subjects when sodium intake was lowered and potassium and magnesium intake was increased by means of a mineral salt. However, before these results can be accepted some aspects of the trial need to be discussed.

We provided salt and foods which were palatable and eaten regularly by the participants in both groups. This was reflected in a persistent difference in sodium and potassium excretion between the study groups. From Dutch food tables¹⁴ the daily magnesium intake was estimated to be 7 mmol higher in our mineral salt group than in the controls though this was not reflected in the urinary excretion values. The intervention effect on blood pressure in the mineral salt group seemed to be fully achieved after eight weeks and persisted throughout the study. After the trial the participants switched back to sodium salt and foods were no longer provided. The difference in blood pressure was no longer detectable 25 weeks after the study. No data on urinary electrolyte values were obtained at that time.

Cutler *et al* reviewed 23 randomised trials and concluded that a 50 to 100 mmol reduction in sodium excretion per 24 hours was associated with a blood pressure fall of 4.9 mm Hg systolic and 2.6 mm Hg diastolic in hypertensive subjects.⁹ A mean reduction of 38 mmol/24 h in sodium excretion was achieved in our study. In a meta-analysis of 19 trials Cappuccio and MacGregor reported a fall in supine blood pressure of 5.9 mm Hg systolic and 3.4 mm Hg diastolic with a threefold to fourfold higher increase in potassium excretion than in this study.¹⁵ Cross-sectional data from the INTERSALT study predicted smaller decreases of 1.9 and 1.2 mm Hg respectively with a similar change in urinary potassium excretion.⁷

A 20 mmol increase in daily magnesium intake resulted in a diastolic blood pressure fall of 3.4 mm Hg in a recent trial among Dutch women.¹⁶ The mean reduction in blood pressure of 7.6 mm Hg systolic and 3.3 mm Hg diastolic in our study, in which daily sodium intake was lowered by 38 mmol, potassium intake was raised by 18 mmol, and magnesium intake was estimated to be raised by 7 mmol, was larger than we would expect based on these previous estimates. The 95% confidence interval allows for a fall in systolic blood pressure as large as 11 mm Hg.

Several factors could have contributed to the comparatively large blood pressure effect in our study. Firstly, the simultaneous alteration of sodium, potassium, and magnesium intake may more strongly affect blood pressure than a change of one mineral alone. To our knowledge no double blind placebo controlled intervention trial on the combined effect of these minerals on blood pressure has been reported in humans. However, some data on the interaction of sodium and potassium are available. In an observational study Khaw and Barrett-Connor showed a stronger correlation of age adjusted blood pressure with the sodium to potassium ratio than with the individual minerals.⁴ This was confirmed in mildly hypertensive young people.⁵ The increased magnesium intake in our trial could have contributed

Clinical implications

- Hypertension is common among older subjects and a well established risk factor for stroke and heart disease
- Diet affects blood pressure, and changes in diet are recommended as initial, non-pharmacological measures to lower raised blood pressure
- In this study a fall in blood pressure of 8 mm Hg systolic and 3 mm Hg diastolic was achieved by replacing common salt by a low sodium, high potassium, high magnesium mineral salt
- The diet in the trial remained largely unchanged, and the alternative salt and foods were palatable and well accepted by participants
- In the initial management of raised blood pressure it may be easier and more effective to provide a mineral salt than to get patients to restrict salt intake or to take a pure potassium chloride salt substitute

to the reduction in blood pressure, possibly through interaction with sodium and potassium.^{17,18} Moreover, possibly the unique nature of the mineral salt, characterised by its source and double salt structures, also had a beneficial effect.

Secondly, the magnitude of the blood pressure fall could be related to the age of our study population. There is substantial evidence that elderly people benefit more from a reduction in sodium intake than young people.^{7,19} We could not show a modification of the intervention effects with age, but the age range in our study was restricted.

There are many deaths from cardiovascular disease in elderly people. Thus a reduction in blood pressure as observed in our study potentially has important implications for morbidity and mortality in the older population.^{20,21} We could effectively study the combined effect of sodium, potassium, and magnesium on blood pressure with a salt substitute, leaving the diet unchanged. Replacing common salt with the mineral salt resulted in a modest change in the mineral composition of the diet and was well accepted. This provides a practicable and more convenient dietary intervention than trying to get patients to restrict salt intake or to take a pure potassium chloride salt substitute.²²

In conclusion our findings indicate that replacing sodium salt with a low sodium, high potassium, high magnesium mineral salt could offer a valuable non-pharmacological approach to lowering blood pressure in mild to moderate hypertension, especially in older people.

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Relation between biochemical severity and intelligence in early treated congenital hypothyroidism: a threshold effect

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Abstract

Objectives—To assess whether early treatment of congenital hypothyroidism fully prevents intellectual impairment.

Design—A national register of children with congenital hypothyroidism who were compared with unaffected children from the same school classes and matched for age, sex, social class, and first language.

Setting—First three years (1982-4) of a neonatal screening programme in England, Wales, and Northern Ireland.

Subjects—361 children with congenital hypothyroidism given early treatment and 315 control children.

Main outcome measures—Intelligence quotient (IQ) measured at school entry at 5 years of age with the Wechsler preschool and primary scale of intelligence.

Results—There was a discontinuous relation between IQ and plasma thyroxine concentration at diagnosis, with a threshold at 42.8 nmol/l (95% confidence interval 35.2 to 47.1 nmol/l). Hypothyroid children with thyroxine values below 42.8 nmol/l had a mean IQ 10.3 points (6.9 to 13.7 points) lower than those with higher values and than controls. None of the measures of quality of treatment (age at start of treatment (range 1-173 days), average thyroxine dose (12-76 µg in the first year), average thyroxine concentration during treatment (79-234 nmol/l in the first year), and thyroxine concentration less than 103 nmol/l at least once during the first year) influenced IQ at age 5.

Conclusions—Despite early treatment in congenital hypothyroidism the disease severity has a threshold effect on brain development, probably determined prenatally. The 55% of infants with more severe disease continue to show clinically significant intellectual impairment; infants with milder disease show no such impairment. The findings predict that

10% of early treated infants with severe hypothyroidism, compared with around 40% of those who presented with symptoms in the period before screening began, are likely to require special education.

Introduction

Before the introduction of routine neonatal screening for congenital hypothyroidism in the mid-1970s¹ it had been reported that treatment during the first few months of life was associated with better psychological outcome.² This led to considerable optimism that early treatment would eradicate the intellectual impairment associated with the disorder. Though psychological progress in children detected by screening has generally been good,³⁻⁸ some studies have produced evidence of deficits in psychological performance.^{4,8} Opinions differ on whether these deficits relate most closely to the biochemical severity of hypothyroidism,^{4,8} bone age at diagnosis,^{4,5} age when treatment is started,⁹ or the quality of thyroxine replacement therapy.^{3,7,10}

We examined psychological outcome in a cohort of 361 children with congenital hypothyroidism born between 1982 and 1984 and treated in the United Kingdom after the introduction of the national screening programme in 1982. We also examined the relation between outcome and different factors in diagnosis and treatment and reassessed the psychological benefits which have been achieved in the United Kingdom by early diagnosis and treatment.

Subjects and methods

Of the 1 972 590 infants born in England, Wales, and Northern Ireland (Scotland was excluded) between 1 January 1982 and 31 December 1984, 489 were identified as congenitally hypothyroid in neonatal screening tests.¹¹ Of these, 472 had persistent hypothyroidism (thyroid stimulating hormone concen-

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